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June 2, 1988

BP Minerals, America
1515 Mineral Square
Salt Lake City, Utah 84112

SHB Job No. E87-2038B

Attention: Mr. Gerald Schurtz

DIVISION OF
OIL, GAS & MINING
RECEIVED
JUN 9 1988

Re: Geotechnical Investigation Report
Waste Rock Dumps
Barneys Canyon Project
Salt Lake City, Utah

Gentlemen:

It is understood the Utah Division of Oil, Gas and Mining (UDOGM) has expressed concern with regards to the stability of the Mel-Co waste dumps under seismic conditions generating ground motions equal to the magnitude 5.2 event which occurred on September 2, 1962 with an epicenter located in Magna. Additional concerns were raised regarding the possible landslide features which were identified during our site reconnaissance.

Based upon the results of our stability analysis, the waste rock dumps associated with the Barneys Canyon Project should remain stable during a seismic event generating on-site accelerations on the order of 0.2g to 0.3g. The 1962 earthquake in Magna generated estimated accelerations in rock at the project site on the order of 0.16g.

The results of a second reconnaissance to the project site indicates the previously indentified landslide features represent old slope movements with no evidence of recent movement. It is concluded, that surcharges from waste dumping operations should not reactivate these ancient slide masses.

Waste Dump Stability

The results of our stability analyses indicate a static factor of safety equal to approximately 1.2 for the critical dump sections identified. Pseudostatic solutions of the most critical slip surfaces were also performed to evaluate the seismic stability of the waste dumps for horizontal accelerations up to 0.3g. The pseudostatic factor of safety of the dumps approaches 1.0 at a horizontal ground acceleration of approximately 0.1g.

The pseudostatic method of analysis utilizes a constant horizontal acceleration or seismic coefficient. A factor of safety less than unity is indicative of deformation occurring along the failure plane, however, no information regarding the relative magnitude of this displacement is obtained from a psuedostatic analysis. In order to evaluate the magnitude of this deformation, a Makdisi & Seed (1977) analysis was performed for a range of horizontal accelerations up to 0.3g for the final 1.32 to 1 (horizontal to vertical) slope. This permanent deformation-type of analysis accounts for the dynamic characteristics of the embankment and the nature of the ground motions created by the design earthquake. This type of procedure has been recommended for use in mine dump design by by Glass (1985).

Parallel to the Makdisi & Seed analysis, performance records of similar embankments under severe earthquake loadings were

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* References will be listed at the end of report

reviewed and considered in the design. Both the permanent deformation analysis and the review of case histories indicate that permanent deformations under a horizontal acceleration of 0.2 to 0.3g for the critical failure zone would be less than 2 feet. This is considered well within safe limits for the proposed facility.

Based upon a review of the available literature, no seismically induced failures of mine waste dumps within this country have been reported. It should be further noted, the existing Bingham Canyon waste dumps experienced the September 2, 1962 earthquake event (M=5.2) with an epicenter located in Magna. No evidence of failure or deformation within these existing active dumps was noted.

In view of the stiff foundation conditions, the proposed waste rock pile is in the category of embankment stability where no appreciable reduction of shear strength takes place as deformation occurs under dynamic loads. Thus, for a horizontal ground acceleration exceeding 0.1g, deformation of the dump would only occur during the application of the seismic forces. Post ground shaking, flow type movements associated with a liquefaction of the waste materials would not be expected to occur.

Shear strength parameters of the waste dump materials were selected based upon a summary of triaxial shear testing performed over the past 38 years on rockfill materials as reported in the engineering literature (Leps, 1970; Marsal, 1974; Donaghe & Cohen, 1978; Barton & Kjaersli, 1981).

Lower bound values representing weathered, relatively soft granite, were selected for the stability analysis. It is believed that these lower bound values which apply to lower density, poorly graded and weak particles, provides the basis for conservative selection of shear strength parameters for the Mel-Co waste rock dump and adequately accounts for the effects of weathering of the dump and/or variation in the nature of the ore.

Shear strength parameters for the subgrade soils were selected based upon the results of a series of direct shear tests which were performed on undisturbed and remolded subgrade samples as part of the investigation for the heap leach pads to the east of the waste rock dumps. It should be noted, that the strength values obtained for the undisturbed samples can be considered a lower bound due to undisturbed soil sampling methods. Representative undisturbed samples could not be obtained of the more well cemented or granular strata; thus the samples tested for shear strength parameters are inherently the softer materials.

Classification index properties of the samples tested are similar to the subsoils of the waste rock dump sites as are the in-place consistencies as measured by Standard Penetration blow counts. Accordingly, these values are considered representative of the site subsoils.

Effect of Ancient Landslides

As noted in our report, topographic features were identified within the site area which may be indicative of the presence of ancient landslides. These features could not be definitely identified as landslides at the time of our original investigation due to snow cover. A second reconnaissance was performed on May 25, 1988 to assess these possible landslide features and their relative stability. Based upon the results of this recent reconnaissance and a review of recent aerial photographs, it is believed these features represent old slope movements, probably of Pleistocene age. These slide masses have remained stable for many thousands of years and appear to have reached equilibrium. No evidence of recent movement was noted in these areas. It is concluded that surcharges from mine dumping should be of no consequence. Significant grading and/or drainage modifications could alter this situation.

If you have any questions concerning this letter, please contact the undersigned.

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By _____
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